

Chapter 2

Physical and Environmental Setting

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Although only 9,000 acres on LANL lands burned, the Cerro Grande Fire has some impact on virtually all portions of the Laboratory, an area that encompasses a broad range of ecological, geographic, vegetative, and topographic components.

LANL is situated on the Pajarito Plateau. The Plateau consists of a series of narrow mesas and deep canyons that trend east-southeast from the Jemez Mountains to the Rio Grande Valley. The defining feature of the Plateau is that of the Tsirege Member of the Bandelier Tuff, a massive series of ignimbrites or "ash-flow tuffs" that are the result of a series of large eruptions from the Valles and Toledo volcanoes, about 1.4 and 1.1 million years ago, respectively. The Tsirege Member buried much of the former topography between the mountains and the Rio Grande, which ultimately created a new landscape. The subsequent erosion of this relatively recent formation has resulted in the distinctive appearance of the topography of the Plateau, an appearance that is characteristic of LANL (LASL 1976:4–6; Reneau and McDonald 1996:3).

LANL contains several distinct environmental zones. The elevation gradient at LANL is quite substantial at approximately 800 m (2,400 ft), ranging from the Rio Grande Valley (1,620 m or 5,400 ft) to the base of the Jemez Mountains (2,340 m or 7,800 ft). This elevation change and the complex geological history have created several different climatic zones, soil types, vegetative zones (Figure 2.1), and animal habitats (Balice 1998:4–6; Burton 1982:1–6; LASL 1976:2–6; Reneau and McDonald 1996:1–3).

The topography associated with the CGFA Project is typically rugged and undulating, the area contains a number of mesa tops and canyon bottoms and associated steep talus slopes and cliffs. The damage that resulted from the fire is concentrated in the lower elevations in the piñon-juniper woodland as it transitions to ponderosa pine forest, and in the upper elevations, which contain sizable stands of ponderosa pine, such as the Rendija Canyon Tract area. Soils in the canyon bottoms and on the mesa tops of the south and southeastern parts of LANL are mostly Aridisols and Entisols. Throughout the areas affected by the fire there is an abundance of alluvium on the steep slopes, large tuff rock outcrops, volcanic rock outcrops, talus slopes, and gravelly and sandy loams. Several of the impact areas are located on soils with a high agricultural potential, an important asset to the ancient inhabitants of the Plateau.

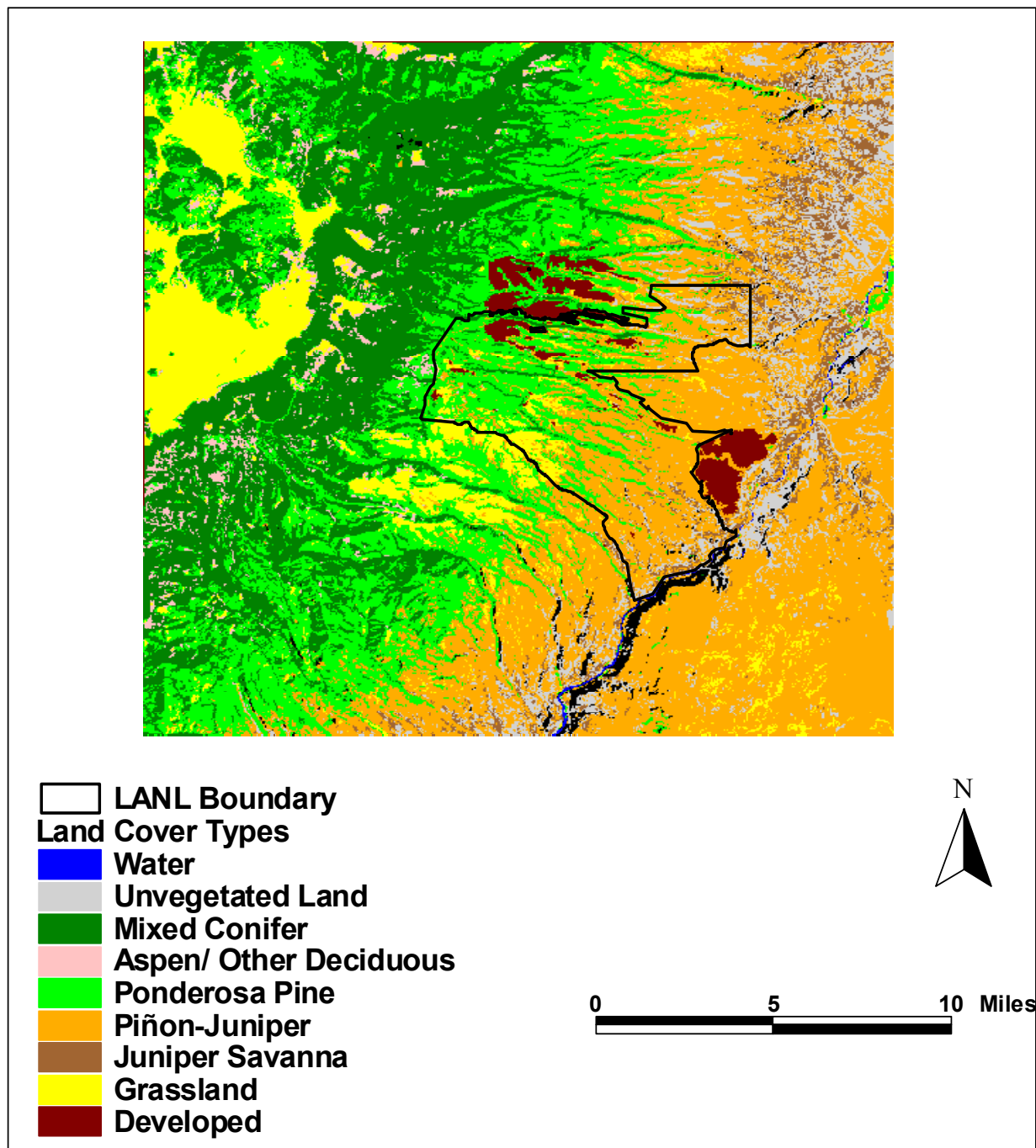


Figure 2.1. The distribution of land cover types at LANL.

GEOLOGIC HISTORY

The Pajarito Plateau is located along the western part of the Rio Grande Rift, a structural depression formed by faulting, extending from southern Colorado to northern Mexico. In the LANL area, the Rift is approximately 60 km wide and includes the Española Valley, the Pajarito Plateau, and the Jemez Mountains (Reneau and McDonald 1996:1-3; LASL 1976:5-7; Nyhan et al. 1978:4-14; Burton 1982:1-

10). The Rift is bounded by the Sangre de Cristo Mountains to the east and the southern extension of the Rocky Mountains, the Sierra Nacimientos, to the west.

The geologic formations at LANL were created by volcanism and sedimentation that began in the late Oligocene or early Miocene (18 to 25 million years ago) (Burton 1982:3–6; Reneau and McDonald 1996:1–5). The oldest rocks in the Los Alamos area are the siltstones and sandstones of the Tesuque Formation. The formation was deposited on a broad floodplain of the Rio Grande Rift. The formation underlies the Española Valley and outcrops along the lower edges of the Puye Escarpment and White Rock Canyon.

The Tschicoma Formation overlies the Tesuque Formation in the western part of the Los Alamos area and forms the volcanic highlands of the Sierra de los Valles. This formation consists of andesites, dacites, rhyodacites, and quartz latites. Radiometric dates of the flow rocks range from 3.7 to 6.7 million years ago. The thickness of this formation is estimated to exceed 800 m (LASL 1976:5; Nyhan et al. 1978:13–15).

The Puye Formation is a fanglomerate, made up of volcanic debris, which has eroded from the volcanic pile. The formation is exposed in grayish-buff cliffs primarily along the Puye Escarpment and in White Rock Canyon. This formation is also exposed in deeper canyon cuts on the eastern edge of the Plateau. The Puye Formation consists of angular to sub-rounded boulders and cobble rocks that rest in a matrix of sand and gravels. Thin beds of ash and pumice are commonly associated with this formation. At its greatest thickness, the conglomerate exceeds 200 m near the center of the Pajarito Plateau.

The basalt rocks characteristic of Chino Mesa are present in outcrops along White Rock Canyon, particularly in Technical Area (TA) -70, -71, and -54. Basalt overlays the Tesuque Formation and interfaces the Puye Formation to the west. The dark gray basalts originated as a series of flows and intrusive sediments; these deposits exceed a thickness of 350 m (LASL 1976:8).

The Bandelier Tuff forms the upper surface of the Pajarito Plateau. The lower Guaje Member is an air-fall pumice with a thickness that ranges up to 10 m. The middle Otowi Member is a massive non-welded rhyolite tuff that was laid down as an ash-flow. Its thickness is as much as 80 m. The upper Tshirege Member is a series of ash flow and ash fall, which includes non-welded to welded units of rhyolite tuff. The Tshirege Member is a cliff-forming unit that is found in canyons that are cut into the Plateau. The Member is quite substantial, and the thickness of it in the western part of the Plateau exceeds 250 m (LASL 1976:8; Reneau and McDonald 1996:7–16).

SOILS

In the LANL area there are several different types of soils and unconsolidated materials that overlay the natural bedrock. Of the 10 different soil orders, only five exist on LANL property: Alfisols, Aridisols, Entisols, Inceptisols, and Mollisols. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings to pedogenic processes. The Entisols are an exception to this and can form in many different climates (LASL 1976:14, Nyhan et al. 1978:14–25). The Inceptisols and Mollisols are generally confined to the higher elevations at LANL. As they make up only a small portion of LANL soils, they will not be further considered here.

Approximately 80% of Los Alamos County soils can be grouped into the Alfisol, Entisol, and Aridisol soil orders. Aridisols are soils that form in arid climates that commonly go through prolonged dry periods—greater than 90 consecutive days—in which there is no available water. Aridisols primarily occur at the lower elevations in the southeastern portion of the Laboratory. Plant communities found in

association with Aridisols at LANL consist primarily of piñon-juniper woodlands, with ephemeral grasses, forbs, and other scattered plants such as cacti.

Alfisols develop where water is available for plants during at least 90 days when it is warm enough for plant growth. These soils occur at higher elevations along the base of the Jemez Mountains. They have significantly more clay and develop in forested areas (for example, ponderosa pine).

The Entisols have little or no evidence of development, in contrast to the Alfisols. The Entisols are found intermingled with the Aridisols and Alfisols on several low-elevation areas in the southern and southeastern portions of LANL mesa and canyon landscapes. Entisols are found on the erosional surfaces of steep slopes, or on floodplains that frequently receive new deposits of alluvium (Nyhan et al. 1978:14–25; LASL 1976:14–16).

There are several different soil series at LANL. Because of topographic location, it is noteworthy that some of these soils have a greater agricultural potential than others. The agricultural potential is based on soil depth, water capacity, and slope. This soil information comes from two different studies, one for Los Alamos County and one for Santa Fe County. As is common for Soil Conservation Service reports for adjacent counties, the names of soil series differ. Because of these differences in nomenclature, it is difficult to correlate the series in each study. All of the different soil types are discussed in detail in Hoagland et al. (2000:2.3–2.5).

CLIMATE

Los Alamos is characterized by a semiarid, temperate mountain climate. Mean temperatures vary with altitude, averaging 5°F (3°C) hotter in and near the Rio Grande Valley (1,980 m; 6,500 ft) and 5°F to 10°F (-3°C to -5.5°C) cooler in the nearby Jemez Mountains (2,600 to 3,050 m; 8,500 to 10,000 ft) (Bowen 1990:3–17).

In general, winter temperatures range from 15°F to 25°F (-9°C to -4°C) during the night and from 30°F to 50°F (-1°C to 10°C) during the day. Cold arctic air masses occasionally invade the Los Alamos area from the north and east, but often the shallow layer of coldest air is dammed to the east by the Sangre de Cristo Mountains. Temperatures in the Los Alamos area occasionally will drop to 0°F (-18°C) or below. The freeze-free growing season of 157 days in Los Alamos is relatively short. The average normal growing season in White Rock is even shorter at 145 days. Above 2,743 m (9,000 ft), frost can occur at any time of the year, which makes these areas unsuitable for agricultural pursuits (Bowen 1990:3–17; Reneau and McDonald 1996:2–3; Nyhan et al. 1978:9).

The mean average annual precipitation in Los Alamos, including both rainfall and snowfall, is approximately 46 cm (18 in.). Average annual precipitation decreases rapidly as you move toward the valley; the mean average precipitation in White Rock is 33 cm (13 in.). Annual precipitation in the Jemez Mountains is normally higher than either White Rock or Los Alamos at a minimum of 51 cm (20 in.). The precipitation in the area is characteristic of a semiarid climate where variations in precipitation are quite large from year to year. The annual precipitation extremes range from 17.77 to 77.06 cm (6.08 to 30.34 in.) over a 69-year period, the majority of which falls during the summer monsoon season (Balice 1998:1–12; Bowen 1990: 3–17; Nyhan et al. 1978:9–12).

Monsoon rains fall during the months of July and August. At these times, the convection of warm air over the Jemez Mountains causes thunderclouds to develop in the afternoon and early evening; these storm fronts drift out over the Pajarito Plateau, causing brief, but intense rainstorms (Bowen 1990:3–17). Westerly winds, common at this time of year, push the thunderstorms up and over the Jemez Mountains

towards Los Alamos. Up to 40% of the annual precipitation falls during these two months. Winter precipitation falls primarily as snow, with accumulations of approximately 130 cm (51 in.) seasonally; as is the case with the rains in the area, snowfall levels vary considerably from year to year.

PLANT COMMUNITIES

LANL's ecosystem is diverse due to the dramatic 1,500-m elevation gradient between the Rio Grande Valley to the east and the Jemez Mountains and to the presence of many steep canyons. Mesa orientation, solar radiation, and differences in soils and moisture levels contribute to the presence of highly varied ecotones found throughout the Pajarito Plateau. The elevation gradient and the corresponding variable climatic conditions in the LANL region are reflected by the presence of five major vegetation types. These major types are defined by their dominant tree species and by their structural characteristics. These types are juniper savannas, piñon-juniper woodlands, ponderosa pine forests, mixed conifer forests, and spruce-fir forests. Figure 2.1 illustrates the distribution of these vegetation types across LANL.

Within these five general vegetation types, there are several specific vegetation communities, which are not primarily influenced by elevation or climatic gradients. These communities are the aspen forests, grasslands, scrublands, floodplains, open water, and non-vegetated lands. These communities are influenced by a variety of topographic features, including soils, geologic structures, and moisture conditions (Balice 1998:4–29; Balice et al. 1997:3–29; LASL 1976).

Juniper savannas are common between elevations of 1,768 m (5,800 ft) and 1,951 m (6,400 ft). One-seed juniper is typically the only overstory species in the juniper savanna. Grama grasses dominate the understory, but blue grama grasses, hairy grama, and false buffalo grass are also widely distributed as co-dominant species. The average annual precipitation in this zone is approximately 25.4 cm (10 in.) (Balice et al. 1997:17).

Piñon-juniper woodlands are found between 1,890 m (6,200 ft) and 2,195 m (7,200 ft) in Ancho, Water, Sandia, and Los Alamos Canyons. On mesa tops these woodlands are the predominant vegetation type. Juniper is co-dominant with piñon in this community particularly at lower elevations. Piñon increases in importance at higher elevations. The average annual precipitation in this area is approximately 30.5 to 35.5 cm (12 to 14 in.) (Balice et al. 1997:18).

Ponderosa pine forests extend to as low as 1,890 m (6,200 ft) in some of the topographically protected canyons such as Ancho and Water. In more open canyons, like Sandia and Los Alamos, ponderosa pine is not normally found below 1,921 m (6,300 ft). On the mesa tops and the lower slopes of the Sierra de los Valles, ponderosa pine forests extend to 2,378 m (7,800 ft) in elevation. The ponderosa pine is the only overstory species found throughout most of the higher elevation range. However, at lower elevations juniper is also present, and at higher elevations an occasional Douglas fir may be found. The understory characteristic of this community commonly consists of kinnikinnik, Colorado barberry, and Gambel's oak in addition to numerous species of herbs and grasses in the forb layer (Balice 1998:14–18; Balice et al. 1997:19).

Mixed conifer forests appear at higher elevations in the mountains and consist of trees that are at least 5 m (16 ft) tall. Douglas fir, also known as white fir, is the dominant overstory species, although other tree species may also be present in the overstory or mid-story. On north aspects of canyons and on the canyon bottoms above 2,104 m (6,900 ft), the mixed conifer forest intergrades with ponderosa pine communities. In flat areas or on eastern exposures the mixed conifer forest extends to 2,591 m (8,500 ft). In protected drainage bottoms and on southern exposures, mixed conifer forests extend to 2,744 m (9,000 ft). Some limber pine may be present sporadically. The understory may consist of several shrubs, including

ninebark, wild rose, cliff bush, and dwarf juniper along with numerous species of herbs and grasses. The average annual precipitation ranges from 51 to 76 cm (20 to 30 in.) (Balice 1998:14–18; Balice et al. 1997:19).

Spruce-fir forests are widely distributed throughout the highest elevations in northern New Mexico. They can be found on northern aspects as low as 2,439 m (8,000 ft) and on more exposed slopes as low as 2,591 m (8,500 ft). The spruce-fir communities continue to the highest elevations in the Los Alamos region, approximately 3,138 m (10,441 ft). Engelmann spruce and Douglas fir are the dominant tree species in this community. Aspen is also a major overstory species on exposed slopes above 2,683 m (8,800 ft) that have been burned in recent decades (Balice 1998:14–18; Balice et al. 1997:19).

Aspen forest communities are common at mid-elevations in the mountains. They range in elevation from approximately 2,700 to 3,030 m (8,900 to 9,950 ft). Below 2,820 m (9,250 ft), aspen stands occupy the northern and northeastern aspects; whereas, above this elevation, they are mostly found on southeast- to southwest-facing positions. Aspen is present in the overstory with at least 20% ground coverage. Combinations of Douglas fir, ponderosa pine, white fir, or Englemann spruce are also present, but do not dominate the overstory, either as an individual species or together (Balice 1998:14–18; Balice et al. 1997:19).

Scrublands are identified by the presence of shrub species that are greater than 0.46 m (1.5 ft) in height and with at least 15% ground cover. Trees are largely absent within scrubland communities, and when they are present occupy less than 10% of the ground coverage (Balice et al. 1997:31).

Grasslands are identified as areas dominated by grama grasses and other grass-like plant species. Forbs and other non-shrubby species may be co-dominant in these communities. Trees and shrubs taller than 0.46 m (1.5 ft) or equal to less than 15% coverage are absent. Sub-alpine grasslands occur above 2,743 m (9,000 ft) on steep, southerly and southwesterly slopes. Sub-alpine grasslands occur in stony or boulder soils that create conditions that are not wet enough to support the establishment of tree species. Grasslands may also be perpetuated as a result of wildfires (Balice 1998:26; Balice et al. 1997:32).

FAUNAL COMMUNITIES

Several animal communities of both invertebrates and vertebrates are represented at LANL. Many species of small mammals such as mice, wood rats, moles, squirrels, and chipmunks occur in the area, some of which inhabit specific elevation gradients. At least 15 species of small mammals, such as cottontail, jackrabbit, and bats, are also present within the boundaries of LANL (Biggs et al. 1997:1–3; LASL 1976:24–27). This part of the Pajarito Plateau is also home to a number of large game animals, including mule deer and elk. Little is known about other large and medium size mammals in the area, but based on observations and several studies, a minimum of 12 carnivore species are present; among these are black bear, mountain lion, bobcat, fox, and coyote (Biggs et al. 1997:1–3; LASL 1976:24–27).

Cold-blooded animals in the area include several species of fish that inhabit the Rio Grande. The carp, chub, white sucker, and carp-sucker are abundant in the waters of the Rio Grande on the eastern boundary of LANL. Small numbers of brown trout have been reported in the area, but not enough to represent a significant population, a fact likely due to the turbidity of the river (LASL 1976:25). In addition to fish species, there are approximately nine species of reptiles found within the LANL area, including several types of small lizards and king, bull, garter, and rattlesnakes. The Jemez Mountains salamander is a rare amphibian also found in the area (LANL 1998).

Some 187 species of birds, representing about 44 families are reported in the area, some of which are permanent residents while others are transients. Observed permanent residents include the common raven, pygmy nuthatch, western bluebird, gray-headed junco, several owl species, and rufus-sided towhee. Summer birds include the turkey vulture, red-tailed hawk, American kestrel, peregrine falcon, chipping sparrow, and violet-green swallow (Travis 1992).

There is an obvious relationship between the ecological and topographic characteristics of the area, these relationships impact the kinds of species inhabiting various areas of the Laboratory. Coyote, rattlesnake, bobcat, gray fox, red-tailed hawk, spiny lizard, mule deer, deer mouse, and the desert cottontail are all found in the lower elevation zone (1,700 to 2,000 m; 5,610 to 6,600 ft). In the middle elevation zone (2,000 to 2,400 m; 6,600 to 7,920 ft), particularly in the canyons, coyote, raccoon, mountain lion, American black bear, turkey vulture, American kestrel, golden eagle, gopher snake, rock squirrel, and mule deer can be found. In the same elevation zone (2,000 to 2,400 m; 6,600 to 7,920 ft) on the mesa tops are the American black bear, mountain lion, common raven, pygmy nuthatch, Colorado chipmunk, pine squirrel, and mule deer. The upper elevations (2,400 to 3,200 m; 7,920 to 10,560 ft) are inhabited by the American black bear, mountain lion, green-tailed towhee, hairy woodpecker, Rocky Mountain elk, mule deer, western bluebird, and gray-headed junco (LASL 1976:24–26).

